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Determination of the Diffuse Transmittance of Opal Glass and the Use of Opal Glass as a Standard Diffusor in Light-Scattering Photometers

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IN the light-scattering photometer developed by the authors[1], a removable plate of solid opal glass is used in the primary beam as a reference transmitting diffusor in the evaluation of absolute turbidities for determination of molecular weights. The turbidity equation requires in its numerator the diffuse transmittance T of the opal glass plate, and a diffusor correction factor D to adjust for deviation of the opal glass from a perfect diffusor under restricted conditions of observation.

TABLE I. Diffuse transmittance of opal glass plate (2.2 mm thick, exit face finely ground).

		436 mμ	546 mμ
Diffuse transmittance, previous values[a]	T_u	0.315	0.372
Reflectance of reference Vitrolite/MgO	R	0.889	0.921
Diffuse transmittance, corrected, RT_u	T	0.280	0.343
Diffuse transmittance, determined directly[b]	T	0.278	0.342
	Av T	0.279	0.342

[a] Reference 1, Table I.
[b] With fresh MgO surfaces in reference and comparison beams; interior of integrating sphere freshly coated with MgO; small corrections applied (reference 1, page 774) for displacement of opal glass from interior surface of sphere.

The diffuse transmittance as used here is the ratio of the total flux emerging from the second face of the opal glass plate to the flux incident on the first face in the form of a parallel beam of monochromatic radiation. In our work referred to previously[2] the diffuse transmittance of the plate was determined in an early model General Electric spectrophotometer with white glass (Vitrolite) blocks at the rear of the integrating sphere in both the comparison and the reference beams. Values shown in the first row of Table I were obtained after applying a small correction for the fact that the emergent surface of the opal glass plate was displaced slightly from the surface of the interior of the sphere.

Buc[3] has kindly pointed out to us that these values are subject to a substantial correction since the reference beam is incident on the Vitrolite block whereas the highly diffused comparison beam, except for a very small fraction, is incident on the magnesium oxide lining of the integrating sphere. He suggested that correct results will be obtained either by using in the reference beam a block having a reflectance equal to that of the interior wall of the sphere; or by correcting the values we obtained, multiplying them by the reflectance of the Vitrolite relative to that of the sphere wall.

We have accordingly redetermined the diffuse transmittance of our opal glass plate in the General Electric spectrophotometer, with the results shown in Table I.

Thus errors of +11 and +8 percent at the two wavelengths were made in our original determination of diffuse transmittance. These errors, however, will not be propagated to our determinations of absolute turbidity and molecular weights. This is because the product TD appearing in the turbidity equation was experimentally determined in the photometer by comparison of the opal glass transmitting diffusor with several reflecting diffusors under specified conditions, and was not dependent on our determination of T. This product is

$$TD = 0.707RG_0/G_R, \tag{1}$$

where R is the absolute reflectance of the reflecting diffusor, G_0 the galvanometer deflection with the opal glass plate at the table center of the photometer (angle of incidence $i=0°$, angle of observation $\alpha=180°$), and G_R the corresponding deflection with the reflecting diffusor at the table center ($i=-45°$, $\alpha=45°$), the latter corrected for the specular component of reflection. The diffusor correction factor D, required to make the transmitting diffusor equivalent to the reflecting diffusors, was calculated from Eq. (1) after the diffuse transmittance was determined in the spectrophotometer. Obviously, any error in determining this transmittance will result in a compensating error in the factor D, but the product TD is unaffected.

Data originally presented (reference 1, Table II) were recalculated and appear in Table II in somewhat different form, including new observations for magnesium oxide and extension of all data to wavelength 436 mμ. Values of TD are essentially unchanged, the previous values[1] being 0.265 at 436 mμ and 0.321 at 546 mμ. *Turbidities and molecular weights determined with this instrument remain unchanged.* The calculated value of the diffusor correction factor is, within experimental error, the same for both wavelengths. Assuming that the new values of T are correct, it is concluded that, under the conditions of observation in our photometer, opal glass diffusors deviate by about 5 percent from a perfect diffusor (about the same as magnesium oxide uncorrected). In view of Luckiesh's observation[4] that the opal glasses he examined were "practically perfectly diffusing," the new value of D, 0.95, is more reasonable than our previous value (approximately 0.85). As before, it is concluded that all the reflecting and transmitting diffusors, after correction as shown, would give equivalent results as reference diffusors in our light-scattering photometer.

[1] Brice, Halwer, and Speiser, J. Opt. Soc. Am. **40**, 768 (1950).
[2] See reference 1, p. 774.
[3] George L. Buc (private communication).
[4] M. Luckiesh, Elec. World **61**, 883 (1913).

TABLE II. Comparison of opal glass transmitting diffusor ($i=0°$, $\alpha=180°$) with reflecting diffusors ($i=-45°$, $\alpha=45°$).

	436 mμ					546 mμ				
			0.707G_0/G_R					0.707RG_0/G_R		
	R[a]	H/V	Obs	Corr[b]	Obs, Anal[c] H	R[a]	H/V	Obs	Corr[b]	Obs, Anal[c] H
Vitrolite	0.738	0.763	0.226	0.261	0.260	0.816	0.761	0.280	0.324	0.326
$MgCO_3$	0.926	0.872	0.245	0.263	0.263	0.964	0.862	0.295	0.318	0.318
MgO	0.98	0.870	0.247	0.265	0.271	0.99	0.870	0.304	0.327	0.335
Casein paint 1	0.789	0.929	0.262	0.272	0.278	0.885	0.934	0.317	0.328	0.329
Casein paint 2	0.724	0.929	0.253	0.263	0.262	0.814	0.939	0.310	0.319	0.323
Casein paint powder	0.817	0.985	0.260	0.262	0.265	0.871	0.982	0.312	0.316	0.319
				0.264	0.266				0.322	0.325
TD, average				0.265					0.324	
D, calc				0.950					0.947	

[a] Absolute reflectance (reflectance relative to MgO in G. E. spectrophotometer times absolute reflectance of MgO).
[b] Corrected for specular component of reflection by assuming $(1-H/V)/(1+H/V)$ represents the ratio of specular to diffuse component.
[c] Analyzer present (horizontal orientation) when determining G_0/G_R.